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Long Run Scenarios for Surface Transport

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Research Memorandum 1995-29



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March 1995



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ABSTRACT

Current trends in transport **indicate** that the system is moving away from a sustainable development (e.g., due to rising CO₂-**emissions**) and that major **changes** in technology, public policy as **well** as in the behaviour of individuals are necessary to make the transport system more compatible with environmental sustainability. This provokes the need for assessing a set of future images for transport in relation to the environment. In this paper reference and expert scenarios, which **can** act as a judgement framework for a sustainable transport system, are constructed on the basis of the recently developed 'spider model'. Based on a set of distinct characteristics of a transport system, represented by eight axes in the spatial, institutional, **economic** and social-psychological field, an evaluation framework is constructed, which visualizes the driving **forces** that largely influence the future of the transport system. There are several directions in which these **factors may** develop, and **each** of them **will** separately or in combination lead to entirely different transport systems. In this way, **many** scenarios **can** be constructed by connecting points on the **successive** axes. **Such** scenarios **may** range from market-oriented to regulatory pictures; the **first may** lead to a transport system in which individual, the **second** in which **collective** modes of transport dominate.

Next, expected and desired scenarios are constructed by **means** of opinions of Dutch transport experts, which have been investigated by **means** of a nation-wide survey. The expected scenario **indicates** that **many** current trends **will** continue, while the transport system is largely the same as the current one. The desired scenario on the other hand, gives a more **collective** system, in which **also many** new modes are operating. The conclusion is that there are **many** roads for achieving a sustainable transport system, but that whatever road will be **chosen**, this road **will** be hard to follow.

1 INTRODUCTION

Current trends in transport show a worldwide rise in mobility and an ongoing modal shift towards the private **car** and airplane. Consequently, the negative externalities caused by transport, **such** as visual, stench and noise annoyance, spatial segmentation of landscapes, and the emissions of harmful **gases generating** smog and various kinds of greenhouse **effects** are likely to increase and to lead to environmentally unsustainable conditions (Nijkamp, 1994). As a **result** large changes seem unavoidable which **makes** future changes in the transport system necessary (Thord, 1993).

In **general**, externalities caused by transport **may** be reduced by using four options: improvement (technical, managerial) of vehicles, introduction of more sustainable transport **technologies** and of new transport modes, a modal shift towards **cleaner** (mostly **collective**) transport modes and a reduction of the total mobility level (Enquete-Kommission, 1994).

It is **clear** that **the** first option leads to the least resistance in society and to the lowest necessary changes in individual transport behaviour. **However**, current expected improvements in the private **car** and airplane are not expected to **reduce** the externalities to **such** an extent that one could speak of a 'sustainable' transport system, mainly because improvements are simultaneously compensated by growing mobility **rates** (Gwilliam and Geerlings, 1994). Therefore, alternative options have to be considered as well. It seems plausible **however**, that none of the above mentioned four options **will** separately lead to a sufficiently favourable impact on environmental quality conditions.

Therefore, it is feasible to investigate a blend of **all** options in order to attain a more sustainable transport system. For **example**, in the long run several new **technologies may** be **introduced**, which **may largely reduce** the externalities of transport (Rienstra et al., 1995). The same **result may** hold for a **drastic** modal shift and for a reduction in mobility levels. In **practice**, various mixed options **may** thus be **introduced**, which will have different impacts in **many - also non-environmental - fields**, therefore trade-offs have to be made.

In order to **analyze** the potential of **such** mixed options the construction of **scenarios** is an interesting and promising methodological approach (see **also** Swahn et al., 1994). There are several ways of **constructing scenarios**: they **may** be intuitive, a literary product (mostly **historic**), idealistic, qualitative expert assessments or an instrument for quantitative forecasts (Svidén, 1989). Two complementary methods **may** be distinguished; **the first** one is forecasting in which the existing situation is taken as a starting point for exploring the future. The **second** one is backcasting in which **first** the situation in the reference year is given, and next the necessary policy measures and developments to **reach** this situation are described (Steen, 1994).

In the present paper two kinds of **scenarios will** be presented as a vehicle for exploring environmentally sustainable situations in **the** transport sector. **First**, two intuitive reference **scenarios**, which describe extreme developments in several **fields** related to transport and the environment, will be developed. Next, a new type of **scenarios** based on expert opinions will be constructed. These opinions

are gathered and assessed by **means** of a **structured** questionnaire which has been sent to hundreds of Dutch transportation experts. Both the reference and expert scenarios have been **discussed** in an international workshop, too. Like in the Masser et al. (1992) study, several questions have been asked about expected and desired developments which **may influence** the future of transport; hence an expected and a desired scenario **may** be constructed. In the Masser et al. study, various packages of futures are designed and presented, while in our study **each** relevant aspect has been questioned separately. The advantage of this approach is that in this way scenarios **may** be constructed by combining different groups from one sample; this **also** offers the opportunity to investigate in more detail possible inconsistencies in opinion among different segments of one sample.

The paper is built up as follows. First an introduction **will** be given to the methodology used • the so-called spider model • for the scenario construction. Next the reference scenarios • a market-oriented and a regulatory one • are constructed. Then the expert based scenarios are described, while **finally** some conclusions are drawn. We restrict ourselves to passenger transport in Western Europe, while the **time** horizon **chosen** is 2030. For a more detailed analysis as **well** as for a description and underpinning of the questionnaire we refer to Nijkamp et al. (1995).

2 METHODOLOGY USED: **THE SPIDER MODEL**

2.1 Introduction to the Spider Model

Many driving **factors** are important for the future of transport. They **may** be found in several scientific disciplines and **may relate** in particular to spatial, institutional, **economic** and **social/psychological** aspects. In the scenarios **designed** the resulting future transport system is supposed to be a **consequence** of **forces** and developments in **the** above mentioned fields. The most important future developments in these **fields may** be studied by **using** a multi-criteria analysis, which is visualised by **means** of a spider model (see Figure 1). **Multi-criteria** analysis is a method to grasp, classify and analyze different scenarios by **means** of explicitly formulated criteria (which are put on the axes of the spider). The advantage of this analysis is that the individual assessment criteria do not have to be measured in a single **quantitative** unit; they **may** be **qualitative** in **nature** (e.g., rank order) (cf. Voogd, 1983).

2.2 The Spider Factors as Eight Diict Dimensions

For **each** of the four relevant scientific fields distinguished in our study two axes are drawn in the spider, which are the most important **factors** influencing the future of transport and the transportation **technologies** used. On the **first** axis, possible developments **in the future European spatial organisation are** mapped. At the one extreme (interior) **side** of **this** axis we find the so-called **chains** and zones model which is a **result** of a non-interventionist policy and trends which lead to a diffuse spatial **structure**; at the other extreme the **concentration** and specialisation model is depicted which **tends** to favour a **concentra-**

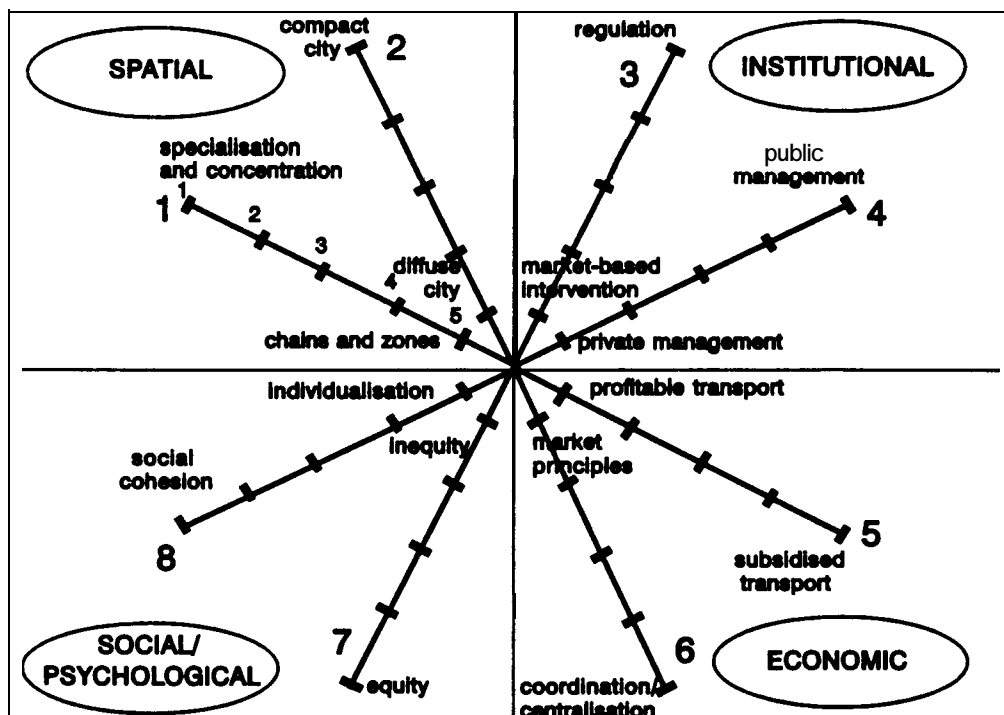


Figure 1 *The spider model for depicting the driving forces of future transport systems*

tion of activities and population in urban areas and in the economic core zone as a result of a dedicated spatial-economic policy (cf. RPD, 1991). The second axis in the spatial organisation is mainly concerned with urban patterns; it describes the important dichotomy between spatial dispersion and concentration. Thus, on the extreme sides of the second axis we have depicted the diffuse city (as a result of free market forces) and the compact city (as a result of explicit urban policy efforts) (see also Wegener, 1995).

In the institutional part (axes 3 and 4) we investigate the controlling and managerial systems for sustainable mobility. On the third axis the degree of government intervention in the transport market is depicted; the contrasting ways are regulation versus market-based measures. The management of transport modes and infrastructure is found on the next axis, where the two extreme ways in which this may be organized - purely public or private - are presented. In this context, public transport means that the ownership as well as the operation of the transport companies are the sole responsibility of the government (or governmental agencies).

Another important driving force stems from the economic field, and is depicted in the axes 5 and 6. The fifth axis concerns the feasibility of transport as the required profitability of transport modes is an important factor for the future of transport. The main question in this case is whether the government wants to subsidise transport or whether transport modes should be operated on a

commercial basis; in this way **also** private financing of infrastructure **may** be **attractive**. This warrants the extreme cases of profitable versus subsidised transport on axis 5. The next extremes - to be found on axis 6 - are the **introduction** of market **principles** in the **economy** versus coordination by the government (which **may** lead to some form of a centralised government). This consideration is important for future **economic** growth, regional development, the construction of infrastructure towards peripheral regions etc.

Finally **socio-psychological factors are** important (see also Levy-Leboyer and Duron, 1991). On the seventh axis equity is confronted with inequity. **Non-intervention may** favour inequity in society (for example, an **uneven income** distribution, **uneven** chances for individuals, e.g. travelling, education), while on the other hand **much** public governance **may** emphasize equity measures (**social** security, discounts on travelling **costs** etc.). Finally, the eighth axis reflects individualisation versus **social** cohesion, which is important from the viewpoint of the level of freedom of individuals (versus **social** control), including related developments (e.g., demographic, educational), which **may** have again **consequences** for transport.

All above mentioned four **fields** (represented **each** by two axes) have important impacts on the level of transport **demand**, the **price** level of transport and the modes used, and hence **may** be regarded as the **main** force fields for the development of transport systems technology.

The order of items on **each** of the eight axes is **such** that the interior points are more associated with non-intervention strategies (e.g., market-forces, **liberal** attitudes etc.), whereas the exterior points reflect the **result** of policy **interventions** (e.g., land use planning, **control** strategies, regulatory measures etc.).

2.3 The Construction of the Scenarios

A transport system **can** now be represented and **assessed** by a combination of 8 points on the **successive** axes of the spider model. This is a meaningful visualisation of the **main** characteristics and driving **forces** of **such** a system, as a confrontation of different 'spiders' (concerned with different driving forces) **will** immediately **pinpoint** the most important underlying factors. It should be recognized that the **size** of the area formed by linking the 8 points on **all** axes has no meaning, as (1) the information on the axes has only a qualitative (and not a cardinal) meaning and (2) **the size** of the resulting area is **also** dependent on the order in which the axes are positioned in the spider.

One **may** wonder why technological developments have not been included as driving forces in the spider model. This would certainly have been possible (e.g., by **making** a distinction between Schumpeterian types of technological **changes** and government-instigated types). **However**, in the present study, technological **advances** in **the** transport sector are regarded as endogenous developments (i.e., responses) to the underlying four major driving **forces**. Thus, in our approach transportation technology is not 'manna **from** heaven', but a **result** of systemic **forces**. Consequently, in the present study a typology of various technological options in the transport sector is made, while next **each** of these options **can** be evaluated by **means** of the elements from the spider model.

It should be noted that the extreme points on **each** axis have only a qualitative meaning; they do not represent numerical information, but only a rank order (in terms of more or less). This is **also** important for scenario design, as the opinions of experts are more concerned with statements on which transport systems options and underlying **forces** are more or less likely than on **precise** assessments of **all** consequences of **such** options. It is possible - or even likely - that in **practice** the expected future developments **will** be less extreme. In that case a shrinkage of the axes **may** take place in order to describe **such** actual developments. Clearly, the **second** and fourth point represent developments which are **closer** to the extremes, whereas the central point (3) **indicates** an intermediate (neutral) development.

Compound scenarios **can** now be **composed**, by taking a point on **every** axis and linking these points. In this way a great **many** of scenarios **can** in theory be designed. The reference scenarios are constructed in **such** a way that they form the inner and outer circle of the spider. They mainly serve as a frame of reference. The expert scenarios will probably combine points at the axes which are positioned more at the middle of the axes. The scenario design itself **will** now be **further discussed** in **Section 3**.

3 REFERENCE SCENARIOS

3.1 The Market-Oriented (**Interior**) Scenario

3.1.1 Introduction

In the market-oriented scenario it is assumed that **all** spider variables **will** develop according to the inner circle of the spider model (see Figure 2).

It is assumed that spatial patterns evolve with a low level of concentration (density), while the public policy is mainly market-oriented and is focused on deregulation and on reducing its direct **influence** on society and the **economy**. As a **result** public intervention in the **economy** is as small as possible, while the necessary (especially environmental) policy measures are largely **market-oriented**. We **will** now describe in more detail the foreseeable developments associated with **the** interior scenario.

3.1.2 Spider **factors** in the market-oriented scenario

Spatial factors

The spatial organisation in the year 2030 is the starting point of this scenario. A shift **will** take place **out** of the cities and the **core** zone towards 'green' rural and partly peripheral regions, which are becoming favourite **places** for living and working, because of **higher** valued living conditions (the suburbanisation trend). Because of mobility **price** increases, in general only the **higher income** classes **will** be able to move to these **areas**. Governments **will attempt** not to interfere, because **every** individual is supposed to be **free** in choosing his or her place of living. At the same **time** the trend towards footloose **companies will** continue, as these **firms** follow the highly educated working force. This **will** especially **be** true

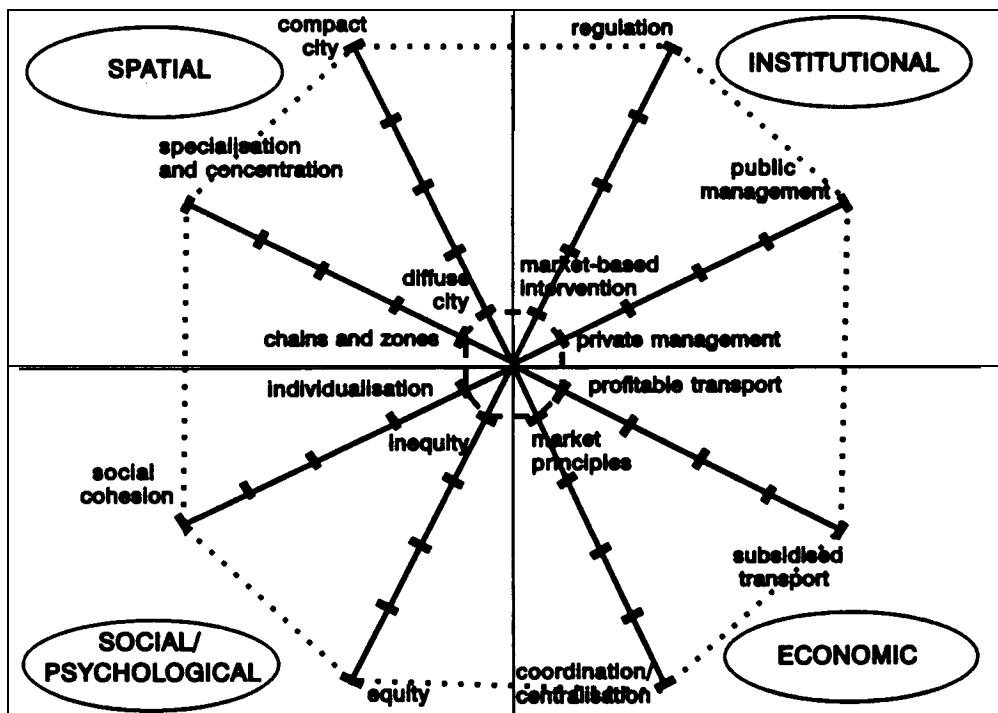


Figure 2 The reference scenarios

Legend ----- market-oriented scenario
..... regulatory scenario

for the most **dynamic** sectors in the **economy**.

As a **result** the peripheral and **rural** regions around large urban **areas** tend to become highly **competitive**, despite the abolishment of regional support **programmes**. Therefore, a diffuse spatial organisation - according to the chains and zones model - **will** occur in **all** countries in Europe. The resulting transport **demand** reflects a **pattern** characterized by **many** low density criss-cross links.

The same trends **will** occur at the urban level. **Every** region has one or more cities, which are the **main** centres of population and **economic** activities. **Because** of the **higher** transport **costs** regions have become more self-supplying, while they have **also** become **rather powerful** because of devolution trends.

The urban organisation which is evolving has **also** a diffuse **structure**. The population of most cities will not grow. The **size** of households **will** decline further, therefore more dwellings are needed to house **the** smaller families. People **who can afford** it **will** move towards 'green' suburbs. The same **holds true** for **many** services like **shopping** malls etc. **Also companies will** follow this trend, because of the poor **and** expensive accessibility of the urban centres. People in the lower **income** classes **however**, stayed behind in the old city centres.

Institutional factors

The devolution trends **will** largely continue. Organisations like the UN, OECD and the Worldbank **will** not get more power, whereas national states become relatively more powerful. There is one major exception, **however**. The global environmental problems (e.g., the greenhouse effect, depletion of the **ozone** layer, **acid rain**) cannot be solved at the national level, because individuals and countries are caught in the social dilemma of 'free rider' behaviour. Therefore, a **strict** environmental policy **will** be agreed **upon all** over the world, while **evasion** from this policy is not possible. An example is a global **CO₂** tax, which **will** increase, for example, the **price** of conventional **fuels** to a large extent. As a **result**, **fiscal revenues** are to a significant extent based on environmental taxes.

Also a **reversal** in the European integration policy **will** occur; as a **result** the regional support and agricultural subsidies **will** largely be abolished. Most emphasis **will** be put on the competitiveness of countries and regions, which **will** reinforce the trends towards governments 'stepping back'. Therefore, there is no **active** housing and physical-spatial policy, while **also** social security systems **will** have been drastically reduced in **size** and coverage.

Also the transport sector **will** be no **main** policy field anymore. **Infrastructure** and the exploitation and operation of networks **will** be largely privatised. As a **result**, for example, user charges (**by**, for **instance** road pricing) **will** be **introduced** at a large **scale**. **When demand** is not **sufficient**, the **infrastructure** **will** simply be **closed**.

Economic factors

The European **economy** **will** develop in a relatively positive direction, because of the introduction of more market **principles** and incentives. Therefore, the European **economy** **will** become more **competitive** compared to other trade blocks. **Because** of the high mobility **costs**, trade growth **will** largely diminish. Despite this, a large share of the population **may still afford** to live in **rural areas**, because of high **economic growth** and rising incomes.

Regional economic growth **will** exhibit more dispersed patterns because of the diffuse spatial development. Therefore, the **economy** in the **core** regions **will** develop in a relatively negative direction, whereas the opposite **holds** for peripheral and **rural** regions.

Policies **will** be **aiming** at internalizing environmental **costs** by increasing the **price** of conventional **fuels**, for example, by implementing a **CO₂** tax, but **also** by introducing levies on noise, **visual** and stench annoyance etc. The variable **costs** of transport **will also** increase because of **the** privatisation of the **infrastructure**. **All** public transport **will** become **also** privatised, while only **basic** safety standards **will** have to be met. **All** transport has become **profitable** in this way, in the **sense** that **all** users **pay** for **all costs** (included social **costs**).

Social and psychological factors

There **will** be a widespread agreement in society that the environment has to be protected, which **will** make global measures possible, despite the **desintegration** of the world community. At **the same time**, the individualisation trend **will**

become more perseverant. Therefore, **evasion** problems **will** likely occur, which **will** make market-based measures more necessary. This trend **will also** lead to a smaller household **size**, which **will** increase housing **needs** and therefore **reinforce** geographical diffusion trends.

Social security systems **will** be largely privatised and minimised; the same **holds** for **all** kinds of public subsidies and government support. A strong **socio-economic** segmentation in society **will come** about; for example, the income distribution **will** become **much** more skew. Therefore, **also** mobility and housing possibilities **may** develop **much** more **uneven**.

Intuitively, society **can** be divided in three income classes: the first class is that of the **rich** people (20% of the population). **They** own a private **car** (based on new **fuels**) and are not restricted by the high mobility **costs**; therefore they **can afford** to live in highly valued natural **areas**.

The middle class **accounts** for about 60% of the population. They **can afford** a private **car**, but they are restricted by the high variable transport **costs**. This class **will** mostly live in suburbs and rural regions. Teleworking **will** become more common, which **will reduce** mobility **needs**.

Finally, the lowest income class (20%) **will** mostly consist of unemployed people, living in old quarters of cities. For their travel **needs** they **depend** on either **car rentals** or (more likely) **collective** modes, because they cannot **afford** to own a private **car**.

Next, we **will** explore the consequences of **this** interior scenario for the transport system.

3.1.3 The transport system in the **market-oriented** scenario

Long distance transport

Because of the diffuse spatial organisation **many** low **demand** criss-cross transport links **will** emerge. The taxes and user charges **will** make mobility **much** more expensive. The environmental taxes will be so high that conventional fuels are to a large extent not used anymore, and will be replaced by new alternative fuels, **such** as hydrogen.

Infrastructure **will** be largely privatised, and **will** be planned, constructed and operated by the private sector. The same **holds** for **collective** modes, which **will** be exploited on a commercial basis. Because of the low density of **demand** on **many** links, the use of **collective** systems **will** largely diminish.

Individual modes will generally be the most **efficient ones**; therefore, the high and medium income classes will own a private **car**. Telematics systems will be **introduced** for **many** transport applications, while on the **main** links route **guidance** **will** become common **practice**. **This** **will** increase the capacity of the **infrastructure** significantly.

Surface **infrastructure** will be strongly taxed because of **the** high environmental externalities, therefore it **will** become **attractive** to construct subterranean transport links for long distances. The same **holds** for existing highways, which **will** be reconstructed as subterranean **infrastructure** or otherwise **closed**. **This** strategy **will** be less **attractive** for conventional rail **infrastructure**, therefore a significant part of traditional rail **infrastructure** **will** be **closed**.

As a **result**, only at high density links High Speed Trains (HST) and Maglev trains **will** be in operation. This **will** especially be the case between large cities **where** high density links do exist. A bus system **will** be set up towards other cities, which are mainly used by people **who** do not own a **car**. On **very** long distances new LH₂ airplanes **may** offer an expensive but environmentally-benign service.

In the beginning of the next century mobility growth **will** be sometimes negative, because of the new environmental taxes. Later on new **technologies** **may** be **introduced** which become cheaper too. Therefore, mobility **will** start to grow again from 2010 onwards. The modal split on long distances **will** change in favour of the private **car**. The share of this mode **will** be about **90%**, with **all cars** driving on new environmentally more friendly fuels.

Urban level

Parallel to the above mentioned long distance transport trend, **also** the cities developed towards a diffuse spatial organisation, while the population **will** not grow to a large extent. **Many** public transport links **will** not be **profitable** anymore, therefore several public transport links will be **closed**. An extensive bus system **will** be set up for people **who** do not own private **cars**.

Private **cars** based on electricity and new **fuels** **will** be the **main** mode of urban transport in 2030, while on shorter distances **also** the bicycle **will** be an important mode in suitable cities. Only at high density links **collective** modes **will** offer a service. A great deal of **infrastructure** **will** be constructed as **subterranean infrastructure**, while **electronic** user charges **will** be levied everywhere.

Because of the shift **out** of the cities, **urban** mobility will decrease in the beginning of the next century, **after** which it **will** stabilize. The modal split of the private **car** will be approximately **70%**, while **collective** modes **will** have a modal share of about 30%.

3.2 The Regulatory (Exterior) Scenario

3.2.1 Introduction

The starting point of the regulatory scenario is a strong concern of the government for land use and transportation **planning** from **the** viewpoint of sustainable development. This **means** a **priority** for a **concentrated** spatial organisation at the European and urban level. It is **assumed** that the government **uses** mainly regulatory measures to **influence** the **economy** and society and **also** the transport market. A **main** reason for this orientation is **also** the **political** emphasis on achieving equity in society.

This scenario forms the outer circle of the spider model and is in this way the opposite of the market-oriented one (see Figure 2).

3.2.2 Spider factors in the regulatory scenario

Spatial factors

In the year 2030 the suburbanisation trend **will** largely be reversed and a shift back towards the cities and the **core** zone **will** occur. This is one of the results of a strict spatial and land use policy, which aims at concentrating activities in the urban and some other **specific** dedicated **areas** in **the economic** heartland of the country and Europe.

Leading **economic** activities **will** be found in a few metropolises • London, Paris, Frankfurt, Milan and Barcelona • which house a large population (10-20 million) and are the **main economic** centres in Europe. **Many** head **offices** of international companies, junctions of HST/Maglev connections and large mainports **will** be found here. **This** trend **will** be reinforced because **(goods)** transport **tends** to become **inefficient** and expensive, which **will** make companies less footloose .

In the next level of the spatial organisation so-called europolles are found, which are relatively large cities (1-5 million) in Europe **with** a sufficiently high degree of specialisation and **economic** potential. They are **often** oriented towards the metropolises, but house **also many** independent activities themselves. Next, smaller cities **will** be found in European **space** in which regional activities are **concentrated**. So a hierarchical spatial **structure will** occur.

These developments **will** have negative impacts on rural and peripheral regions. The population **will** decrease significantly, while **also agriculture** will shift to **areas** in the vicinity of cities. This trend **will** be reinforced by **policies** to make natural reserves of **many** agricultural regions.

At the urban level the compact city concept, **with** a concentration of **economic** activities and population in the city **centre** and some subcentres, **will** emerge as a **result** of a strict housing and industrial policy. It is **very attractive** to live near the nodes of **collective** transport, because otherwise travelling becomes **inefficient** and **very time** consuming.

In old **districts** of the city people live **who** cannot **afford** housing in the more expensive suburban centres. In these **areas** low quality housing is available; **every** destination in these **places can** be reached by public transport, **however**.

Institutional factors

The devolution trends **will** be reversed by 2030; as a **result** there **will** be **much** more emphasis on equity in public policy. Most emphasis will be put on **regulatory** measures, because then **no** distinction is made between people. The EU **will** develop into a centralist organisation with a lot of **influence**. **Strict** and obliged environmental, spatial and transport **policies will** be **introduced** for example. **Also many** protectionist measures were **introduced** to safeguard the European **economy** and to make it easier to introduce regulatory measures to **achieve** sustainability goals.

In socio-economic policy **also much** emphasis on equity **will** take **place**. Social security systems **will** be extended and government interventions **will** be expanded to almost **all** sectors in the **economy** .

Also the transport sector **will** be regulated to a large extent. **Collective** modes **will** be publicly owned, while the maximum amount of **car** kilometres per **person** **will** be restricted, e.g., based on a quota system as a **result** of a **fixed environmental** utility space for transport. Therefore, collective modes **will** become dominant, and their infrastructure **will** be largely expanded. Their **companies** are publicly owned and **will** grow into **bureaucratic** organisations, which **will** be operating at big **losses**. These **will** be **covered** by the government, a policy which is accepted because of the emphasis on equity .

Economie factors

European **economic** growth **will** lag behind that in other trade blocks, because most attention was paid to equity and regulation of the **economy**. Therefore, **economic** efficiency measures and incentives were largely abolished. **Also** taxes have been raised significantly.

The EU **will** introduce a **strict** spatial policy in which activities **will** be **concentrated** in the **core** zone and cities. Therefore, population and **economic** growth **will** be **concentrated** in this zone. To keep the other regions populated **however**, subsidies **will** be given to the rural population to live there. Their activities are largely regulated, in order to safeguard the natural value of these regions.

Transport **will** be running at big **losses**. Because of equity reasons the **prices** for the collective modes **will** be kept low, while **also many** unprofitable links **will** be maintained. To regulate **car** use, restrictions like a maximum amount of **car** kilometres per **person** **will** be **introduced**, therefore there **will** be no need to **price** the road infrastructure by **means** of user charge **principles**.

Social and psychological factors

The low **economic** growth, together with the growing emphasis on equity, **will** **reverse** the individualisation trend. Regulations **will** be accepted as the best way to **protect** the environment therefore. **Evasion** will not be possible because of the growing **social** cohesion. The **size** of households **will** again grow, **also** as a **result** of the scarcity of space because of the spatial concentration trends.

Equity **will** be **the** key topic of public policy. **Social** security systems **will** be expanded, while subsidies and public support **will** increase everywhere. Therefore **social** inequity **will** largely decrease.

Three **income** classes **may** be distinguished. The **class** of **rich** people (approx. 5% of the population) **will** live mostly outside the cities in high quality housing **areas**. **When** they need it (for work or privacy reasons) they are allowed to own a private **car**, driving on new fuels.

About 90% of the population belongs to the middle **class**. They mainly live in compact **centres** and subcentres of **the** cities. For their transport **needs** collective modes **will** be **used**, which they **can** easily **afford** because of the low **prices**. Sometimes, private **cars** **will** be rented, but there is only a limited amount of kilometres per **person** available.

The last 5% of the population consists of unemployed people living outside the city **centres**. They **depend** for their transport **needs** on lower quality **collective** modes, and **can** mostly not **afford** renting **cars**.

3.2.3 The transport system in the regulatory scenario

Long distance transport

By the year 2030 a radial transport system **will** emerge at the European **scale** level, with high density links between the metropolises and from the metropolises to the europolises. **Car** use **will** to a large extent be regulated, and therefore collective modes **will dominate** the scene. This trend **will** be supported by a strong policy **aiming** at spatial concentration and the regulation of **car** use. Road infrastructure investments **will** be drastically reduced, in favour of new investments in rail infrastructure. Because of **lack** of **space** this new rail infrastructure **will often** be constructed as a subterranean network.

On the links between the large metropolises subterranean high speed shuttles **will** offer a high frequency and a high quality service. Between **the** other metropolises and the links towards the europolises High Speed **Trains and** Maglevs **will** be operated, which form the backbone of the transport system. Smaller cities are **also** connected by other fast trains, which are **however** slower than the High Speed Trains. The **connections** with the smaller living and working **areas will** be realized by an extensive network of conventional trains, subways and light rail. In this way **all** Europe is **covered** by a high quality collective mode network. This system offers a high frequency and a good service at low **prices**, so that **almost** everyone **can afford** travelling. The system is subsidised to a large extent **out** of public funds. Air transport **will** be strictly reduced on links **where** other modes are available. At various long distances LH₂ airplanes **will** offer a service.

In the next decade mobility growth **will** be negative because of the regulations on **car** use. **When** new collective infrastructure is constructed **however**, mobility **will** rise again, albeit at a lower growth **rate** because of a stabilising population and the spatial concentration.

The modal split **will** change in favour of collective modes: approx. 80% **will** be **covered** by these modes, **while** about 20% is used by private **cars** (approx. 15% rented and 5 % privately owned).

Urban level

Also in the cities a radial system **will** emerge, with the crowded city **centre** as the central terminal **where** the transport flows **come** together. The **main** corridors are leading to other compact subcentres. The **central** transport nodes are the **HST/Maglev/shuttle** stations or the other conventional **main** train stations. Private **car** use is strongly discouraged, while investments in road infrastructure **will** be drastically reduced. **Walking and** cycling have • in various cities • become the **main** modes for short distances.

The backbone of **the** transport network **will** then consist of subways and light rail connections, **while** on shorter distances **also** people-movers **will** offer a high quality and frequent service. At the nodes of this system low quality modes like **buses** and trams **will still** be in operation and they **will operate** on a relatively dense network. There is **also** a wide spread **possibility** to rent bicycles there. The low quality housing **areas** are **covered** by a network of **buses** and trams too. The density of the network and the low tariffs **will** make the public transport system largely unprofitable, and therefore these modes **will** be largely subsidised. Private

cars are only used to **reach** recreational **areas** or to transport heavy goods. Because of the low price, the mobility level **will** not be restricted by the price but by limitations (travel **time**, destination etc.).

In the first decade of the next century the mobility level **will** decrease because of the **restrictive** measures for **car** use. Later on the mobility **will** start to rise again, as a **result** of the concentration of **economic** and population growth in the cities. The modal share of the private **car** (electric and alternative **fuels**) **will** diminish to **15%**, while **collective** modes **may** account for 85% of the modal split.

4 EXPERT-BASED SCENARIOS

4.1 Introduction

After the extensive description of the two imaginary reference scenarios, we **will** now turn to actual scenario design based on expert opinion. We **will first** give some concise background information.

In **fall** 1994 a questionnaire has been sent to hundreds of previous and current **participants** in the biggest **annual** conference on transportation research in the Netherlands, the so called 'Colloquium Vervoersplanologisch Speurwerk (CVS)'. The survey **contained** an array of questions about the various key **fields covered** by the elements of the spider model, as **well** as about the **viability** and **desirability** of several modes which are at present under development. The response **rate** of the survey was 36% (n = 271).

The questions were consistently subdivided into 'expected' and 'desired' answers, in order to separate factual information and **subjective** value statements of these experts. This **will** allow us to identify **the tension** between reality and wish. Therefore an expected and a desired scenario **can** be constructed, which are presented and described in the remainder of this paper. **Rather** than describing the statistical results of this scenario experiment, we **will depict** the resulting spatial, societal and transport patterns in future by way of interpretative analysis. The resulting scenarios are presented in the remainder of **this** paper. The scenarios **may** be drawn in **the** spider model as presented in Figure 3.

It should be noted that we give here only an aggregate interpretative picture; for **each** subgroup of respondents (depending on age, gender, scientific background or current profession) **such** results **may** be somewhat different.

4.2 The Expected Scenario

4.2.1 Introduction

At **first** sight the expected scenario is largely an extrapolation of current trends, although several behavioural **changes** and policy measures **may** occur. These are not as big and severe as in the desired situation, **however**. Therefore, **also** the resulting transport system does not differ significantly from what is at present. The spider **factors** and the resulting transport system are **discussed** in more detail in the next sections.

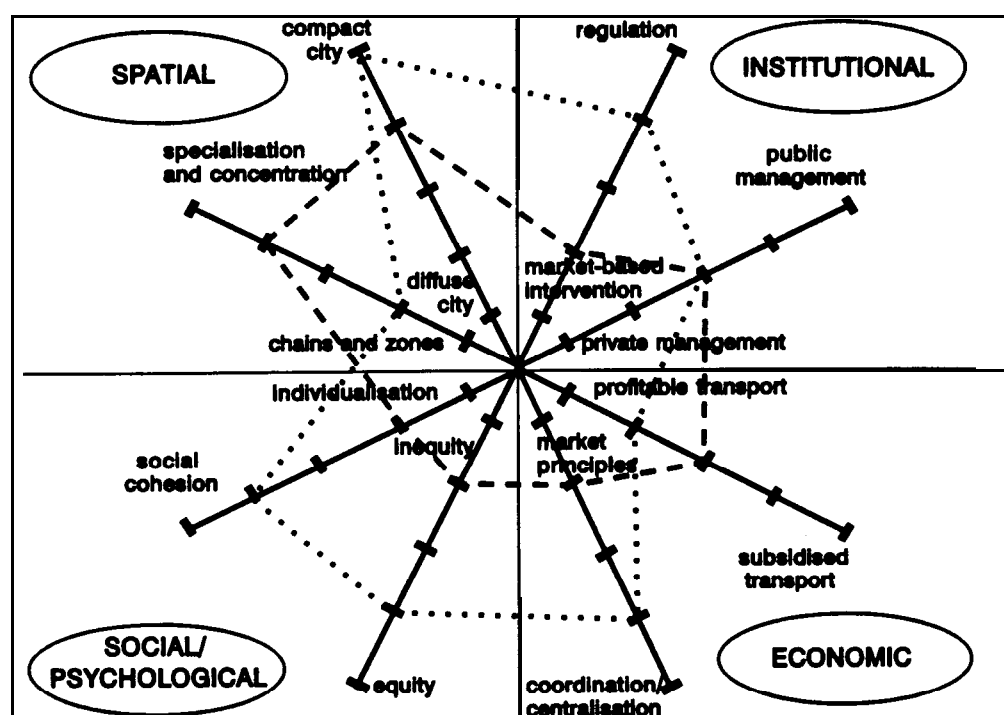


Figure 3 The expert scenarios

Legend ---- expected developments
 desired developments

4.2.2 Spider factors in the **expected** scenario

Spatial factors

The spatial policy is mainly expected to focus on concentrating activities and population in big **urban areas** in order to increase **the** competitiveness of **collective** modes, which **may result** in lower externalities. The suburbanisation trend **will** largely be reversed. Especially richer groups **however**, do not want to move towards the cities; they will either **stay** in the more suburban and rural **areas**. Therefore, a moderate concentration occurs, especially in the **core** regions **where economic** and population growth are the highest.

Several metropolises appear to be **very attractive** for living and working. These are **however** less dominant than in the regulatory scenario because of two reasons. **First**, the spatial policy **will** not be entirely **successful**, and therefore several activities **will** remain in the cities. **Second**, the intensity of European integration **will** largely decline, so that **much** support **will** be given to the **capital** and other big cities in the national **states**. In **almost every** country at least one europolis **will** be found. **Also** the smaller cities **will** appear to be important for the **economy**.

The cities tend to develop towards a moderate compact spatial **structure** too, as a **result** of the public policy pursued. The people tend to be living in **centres**

and several subcentres of cities, because there affordable housing is more available. Several housing problems **may** occur **however**, because of the smaller **size** of households and because of the high **prices** of scarce **space**. Therefore, **also** a large share of the population lives in old living quarters outside the city centres. People **who can afford** it tend to move from the city centres to green suburbs . Therefore, the compact spatial policy is not likely to become **fully successful**.

Institutional factors

In general the devolution trends tend to continue, although the **influence** of the government is **still rather** significant, especially in the spatial and land use field. Most **policies however, will be aiming** at measures to keep the national **economy competitive** with other European countries, with other trade blocks and with the 'low wage countries' . As a **result** the integration of the European **Union may largely** stop, since the population has still a strong **desire** to be governed by national states. At several fields **where** cooperation is favourable for **all** countries (trade policy, environment) the EU **will** gain more influence, **however**.

Also transport **will** remain the **main** responsibility of the national **governments**. At the European level, **strict** standards for emission **levels** for private **cars** were **introduced**, while the same **holds** for telematics standards.

The railway **companies will** be made more independent of **the** national governments, although these governments **will** still be mainly responsible for the construction of **infrastructure**. The profitability of the railway **companies** will be **rather** high for long distance transport. For the other sectors **however**, the **profitability** is fairly low, so that the railway system is still largely subsidised. The same **accounts** for **car** transport, as road pricing for example **will** not be **introduced** at a large **scale**, but only on the most congested links. Public policy will focus mainly at improving current **car** transport and on **the** introduction of electric **cars** in urban transport.

Economic factors

The **European countries will** by the year 2030 largely have integrated their **markets**, but further cooperation is not likely to be achieved. The competition between countries and other trade blocks **tends** to have a negative impact on mutual coordination; environmental **policies**, for example, are probably not centrally **introduced** and **accepted** because of frequent '**free** rider' behaviour of various countries .

The European funds for **the** rural and peripheral regions **will** largely be **abolished**, while at the same **time** a shift towards the **core** zone of individual **countries will** be probable. Therefore, the **core** regions develop relatively positively, while the peripheral and rural regions **will** face a period of relative decline.

The government is largely expected to withdraw **from** the transport market, especially from transport on the **longer** distances. There **tends** to be **much** resistance in society against closing public transport links, and therefore **the** regional and urban transport system **may** still be subsidised to a large extent. Road pricing will not be largely **introduced** on road **infrastructure**, while **also**

other measures to restrict **car** use were not **introduced** at a large **scale**. As a **result** the private **car** **will** still be the dominant mode of transport.

Social/psychological factors

The individualisation trend in society **tends** to continue at the current **pace**. As a **result**, a society with more and smaller households is likely to occur. **Social** cohesion **may** therefore be further reduced, which **will** increase **evasion** behaviour. Behaviourial **changes** **will** therefore not be big enough to change the transport system to a large extent. The individualisation **may also** partly obstruct the spatial policy of **the** government. The same **holds** for measures **aiming** at reducing **car** use and stimulating a shift towards **collective** modes.

At the same **time** **social** security systems **may be** abolished; the same **will** hold for **many** subsidies, for example, in public transport. **Also** taxes **will** be lowered to improve the competitiveness of the national **economies**.

Three **income** classes **may** be distinguished. The **class** of **rich** people (15 % of the population) **can afford** to live outside the cities and in green suburbs. They **will** own a private **car** used for most transport **needs**.

About 75% belongs to the middle **class**, which mainly lives in **the centres** and subcentres of the cities. They own a private **car**, which is powered by **conventional** fuels or by electricity. The **latter** **will** be relatively cheaper because of mass production of the batteries, while there **will also** be government support for this mode. The low driving range is likely to be a problem **however**. Therefore, the electric **car** **will** probably not become the dominant mode. **Collective** modes **will** be more **attractive** on dense transport links, which is **often the** case between the compact city **centres**.

The lowest **income class** at last, **accounts** for some 10% of the population. This **class** **will** mainly live in the old living quarters, **where** housing is cheap but of low quality. They **often** cannot **afford** a private **car**. High quality nodes (**HST** and **main** train stations) **may** be **rather** remote, and **can** only be reached by low quality modes like bus and tram. Their mobility possibilities tend to be largely reduced, therefore.

4.2.3 The transport system in the expected scenario

Long distance transport

In **general**, by the year 2030 a radial transport system **will** occur with **rather** high **density** links between **the** metropolises and mutually between the **metropolises and** europoles. On these links high quality HST-trains will offer a frequent service, **and they will** be **mainly used** for transport between compact city **centres**.

Most people **will use** private **cars** for transport which are driven by **conventional** **fuels, however**. The engines have become **much** more economical, **therefore** the emissions of harmful **gases** **will** be reduced significantly. On **very** long distances airplanes will offer a service. Their use **will** become **rather** expensive because of tax increases, **while** the HST **will** become an important competitor. Subterranean transport **will** appear to be **very** expensive, while most people **still** have to **overcome** psychological barriers for travelling in long tunnels.

For connections with the smaller cities **also** slower trains **will** be in operation; **the** same **holds** for the **main** regional links. On these links the private **car** is **also** the dominant mode, **however**.

Mobility growth **will** largely continue, although it **will** be lower than in the 1990s because of the **changes** in the spatial organisation. **Infrastructure** investments **will** not rise dramatically. Road infrastructure capacity **tends** to be increased by using telematics, while public budgets are likely to be **insufficient** for large **scale** investments in collective mode infrastructure.

The modal split at **longer** distances **will** remain in favour of the private **car**, which **will** account for about 70% of transport **demand**. **Collective** modes **will** account for 30% of the modal split; their modal share between metropolises and **europoles** **will however** be relatively high with about 50%.

Urban transport

Also in the cities a radial transport system is likely to be established. The **main** links **will** be those between the city **centre** and various subcentres as a **result** of the moderate compact spatial **structure**. These links **will** mainly be served by metro and light rail **connections**. **Also** **buses** and trams are still in operation, but their **importance** **will** decrease because of cuts in subsidies.

In most cases **however**, electric and conventional fuel **cars** **will** be used for transport, especially **when** destinations are not in easy **reach** of high quality collective modes. Their use **will** be made somewhat less **attractive** **however**, by raising the parking fees.

Mobility growth in cities **will** be **rather** low because of the new spatial **structures**. A continuing population growth **however**, **may cause** some new mobility growth. About 60% of the modal share **will** be **covered** by the private **car** (30% conventional and 30% electric), while 40% **will** be served by collective modes.

The overall conclusion is thus that the expected scenario is a modified trend extrapolation **where** new **technologies**, new policy orientations and new styles of living have only a moderate impact on transport systems in the future.

4.3 The **Desired** Scenario

4.3.1 Introduction

We **will** now turn to the elements of the desired scenario. In the survey the same questions as for expected developments were **also** asked for the desired **ones**. 'Desired' in this case **means** developments which are to be desired for the society as a **whole** and not only for the transport system. Therefore it is **also** possible to construct a comprehensive desired scenario. The analysis of these answers shows that individual behaviour should change **much** more, **while** several dedicated policy measures and new **technologies** should be **introduced** to a **much** larger extent. The resulting spider scenario is presented in Figure 3. First the spider **factors** **will** be **discussed** in more detail, then the resulting transport system **will** be analyzed.

4.3.2 The spider factors in the **desired** scenario

Spatial factors

According to the experts, in Europe a policy should be established in which **an** equal regional **economic** development is a **main objective**. As a **result** activities and population should shift **out** of the **core** zone towards more peripheral and rural regions. Especially the **main** regional cities **will** then become **much** more important. As a **result** one **may** not speak of a hierarchical spatial organisation, although the number of inhabitants largely differs per city and region.

In long distance transport government policy should focus more on a modal shift towards collective modes, despite the above **discussed** deconcentration. Activities and population should therefore be more **concentrated** around nodes of the collective transport system. In this way a spatial organisation **may** emerge like the chains **and** zones model, with somewhat more concentration in cities. One might therefore speak of a moderate diffuse organisation.

Also at the **urban** level the public policy should be **aiming** at a modal shift towards collective modes. Therefore, the compact city concept should be implemented more, with a strong concentration around the **main** nodes of the collective transport system (see also **the** regulatory scenario).

Institutional factors

In **general**, the **influence** of the government in **many fields** of society and the **economy** should be increased in order to **redress social** and environmental externalities. The EU should develop as the most important authority in the environmental field. It should introduce more compulsory standards and targets, while **also** the regional support programmes should be extended. Likewise the regional authorities should become **much** more important because of the **subsidiarity principle**.

Much emphasis in policy should be put on equity. Therefore, regulation **may** be **accepted** to be the best way for reducing transport externalities. Because of **evasion** problems **however, also** market-based measures should be **considered**.

A **strict** environmental policy should be **introduced**, implemented **and** respected at the European level. For example, in the transport system **many standards** and regulations should be **introduced**, which make a shift from conventional towards new **fuels** more **attractive**.

Also for transport **the** EU should become the most important authority, while the urban and regional authorities should mainly be responsible for the regional and urban modes. The EU should **also** initiate a large **scale investment programme** in collective mode **infrastructure**. **This** network should cover **all main** transport links.

The railway **companies** should be more independent of public **influence**, although they **may** still be publicly owned. This **may** be possible if the **government** undertakes the responsibility for the **infrastructure** and its **costs**. The profitability should drastically increase, because of the policy measures to make **car** use more **expensive** and the necessary **huge** investments. Especially the efficiency of **railway companies** should largely be increased. Road pricing **may** next be **introduced** to a large extent, so that investments in road **infrastructure**

will also become profitable. As a **result** the transport sector as a **whole** should be operated on a **cost covering** basis.

Economic factors

Much more coordination and centralisation **may** be necessary in society and economy, which **may however** have a negative impact on **economic** growth. This should be accepted **however**, because of equity reasons (**both** regionally and individually). As a **result** the European position in the world economy **may however** become relatively less important.

Because of the regional support and the policy to **achieve** an equal regional development, a **shift out** of the **core** regions towards the other regions is needed. This development **may** be stimulated by a proper spatial and land use policy and regional support programmes. As a **result** the **economic** position of regions **will** converge .

The government should **also** intervene more in the transport market and should oblige railway **companies** to cover **all** transport links. At the same **time** large **price** increases should be avoided in order to stimulate public transport use. As a **result**, the profitability of the railways **may** increase, because of the restrictions on **car** use, an increased efficiency and a concentration of population in compact city **centres**.

On most road networks some form of road pricing systems should be **introduced**, which should discourage **car** use and increase the profitability of the transport sector as a **whole**.

Social and psychological factors

It should increasingly be accepted in society that the individualisation and its impacts cannot continue, because of the great **many** negative consequences for the environment and the welfare of individuals. Therefore, **the** individualisation trend should be reversed. It should be widely accepted that environmental measures are necessary; for example, **car** use should be restricted and **collective** mode use should be stimulated. Equity **may** become a **main objective** of public policy . As a **result**, regional support has to be increased, while also the **social** security systems should not be abolished.

Three **income** classes **may** be distinguished. The **class** of **rich** people (10% of the population) **can** still **afford** to live outside the compact cities in 'green **areas**'. They own a **car** - powered by new **fuels** or electricity -, which is **often** used for reaching nodes of the **collective** transport system.

About 80% of the population belongs to the middle **class**, which lives mainly in compact city **centres**. They **often** do not own a private **car**, because of its high **costs** and the scarce **space** in these **centres**. **When** they need a **car**, it **can** easily be rented, **however**.

The lowest **class** at last (10% of the population) lives mostly in the older living quarters of cities. These **can** only be reached by low quality modes like bus or tram. This **class** depends almost entirely on **collective** modes for their transport **needs**, which decreases their mobility possibilities largely. Nevertheless, these services might to be guaranteed by the government.

4.3.3 The transport system in the desired scenario

Long distance transport

In **general**, a transport system should emerge with **many** criss-cross links between the larger cities. These links are covered by **an** extensive network of HST and fast train links.

Private **car** use should be largely reduced on long distances. **Only** at low density links, **cars**, driving on **new fuels**, might be used. Road pricing has to be **introduced** on the **main** transport links. **Very** long distances **where** no HST links are available **may** be covered by LH₂ airplanes, which **may** almost entirely replace the services of conventional **planes**.

Also the **main** regional links should be served by trains **and** on the smaller distances by metro/light rail systems. Here again **cars may** be used for low density links and to **reach** public transport nodes (especially by the richest **class**).

Mobility growth should be negative **after** the introduction of the measures **aiming** at a reduction of **car** use. **When much** new **infrastructure** will be **constructed** for **collective** modes, the mobility **may** grow again, mainly because of the more diffuse spatial organisation.

The modal split should in **any** case change in favour of **collective** modes, which account for some 75% of travel **demand**. Especially because of the relatively high share in regional traffic the private **car** (driving on new fuels) **may** have a total market share of **20%**, while the LH₂ airplane **may** have a share of 5%.

Urban transport

In the cities a radial transport system should **come** into being, with high density links between a compact city **centre** and **its** subcentres. These links are served by metro and light rail systems, which should form the backbone of **the urban** transport system.

At the short distances **walking** and cycling should be strongly encouraged, because **collective** modes are not **efficient** on short distances. **Sometimes however**, people-movers **may** offer a high quality service at **very** high density links.

From the nodes (terminals) of the metro/light rail systems to the **final** destination trams and **buses may** offer a complementary service. At the end nodes of the metro systems parking **places** should be **constructed**, which **may also** be used by the **richer** classes living outside the urban **areas**.

Mobility growth should become negative as soon as **car** use is restricted. Later on **however**, the mobility **may** start to rise again, because of **the** accompanying **economic** growth. About 75% of transport should in the year 2030 be covered by **collective** modes, while 25% **may** be covered by the private **car** (driving on new fuels or electricity).

5 CONCLUSIONS

Changing **the** transport system in order to make it environmentally more sustainable appears to have significant impacts in **many** fields. The life of individuals **may** be **affected**, for example, by intervening in their choice **where** to live, but **also** the freedom to choose their way of travelling. It should be noticed **however**, that the existing transport system is to a large extent the **result** of developments in other fields. Changes in the emphasis on equity or a **reversal** of the individualisation trend, for example, **will** be largely independent of transport motives, as is shown by past developments. Governments in **democratic** countries **will** usually follow these trends and hence **may** show no (major) intentions to intervene. In this context **also** cultural **aspects** do play a role. In the United States, for example, intervention by the government **tends** to face more **resistance** than in most European countries.

Given the need for a structural reduction of the contribution of transport to global environmental problems, it **may** be **clear however** that several choices have to be made about the future of our transport system and its use. In our study these choices have been presented in an extreme way in two reference **scenarios**. For the current transport system the **basic** choice concerns either improving the existing transport system which is mainly based on individual modes of transport (**by** introducing new **fuels**, increasing fuel efficiency etc.) or introducing a more or less **collective** transport system in order to replace (part of) the current transport system (see also Rienstra et al., 1995).

As might be expected beforehand, the **scenarios** based on expert opinions are not that extreme, but reflect more realism. In our opinion **however**, especially the expert-based expected scenario is **rather conservative**. In **fact, this** scenario is largely an extrapolation of current trends, so it is questionable whether it **will** **lead** to a **sufficient** reduction of externalities. It appears, for example, that new **technologies** are not expected to play a major role in future, while public policy is not expected to introduce the **necessary** policy measures for reaching **environmental** targets.

In the expert-based desired scenario the **rather** traditional choice is made that **collective** modes should dominate the transport scene, while the private **car** is only to be **used** as a **feeder** system for **this collective** system. According to most experts, government policy should aim at achieving **such** a **collective** transport system. A striking finding is that most experts - irrespective of age, **gender**, discipline or professional background - largely agree on both **scenarios**; the **variance** in answers between **the** subgroups was smaller than expected beforehand.

The **final** conclusions **may** be that in the expected situation in the year 2030 environmental goals **may** not be attainable at all, while in the desired situation **much** more government intervention and subsequent **changes** in individual **behaviour** and the transport technology used are necessary. In conclusion, based on our application of the spider scenario model, it appears that **many** roads to an environmentally more benign transport system are possible, but that irrespective of the road **chosen**, it **will** be a hard one to follow. Environmentally sustainable mobility is still more a challenge than a realistic and deliberate policy choice.

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